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(54) Integrating amplifiers

(57) An integrating amplifier circuit comprising an operational amplifier (10) provided with a feedback loop containing a capacitor (12), the capacitor being formed of a sheet of polymeric piezoelectric material such as polyvinylidene fluoride carrying opposed electrodes. The embodiment of Fig. 1 is useful as a d.c. force transducer. An alternative embodiment (Fig. 3) is described which is useful as a loudspeaker.

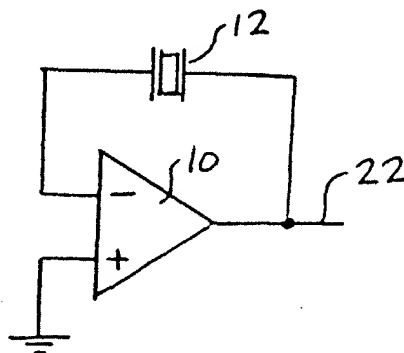


Fig. 1

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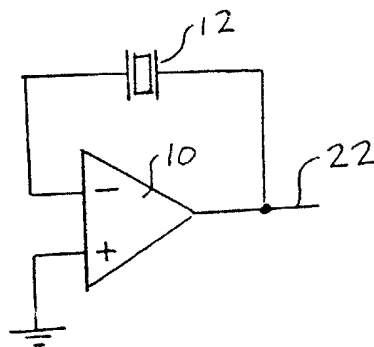


Fig 1

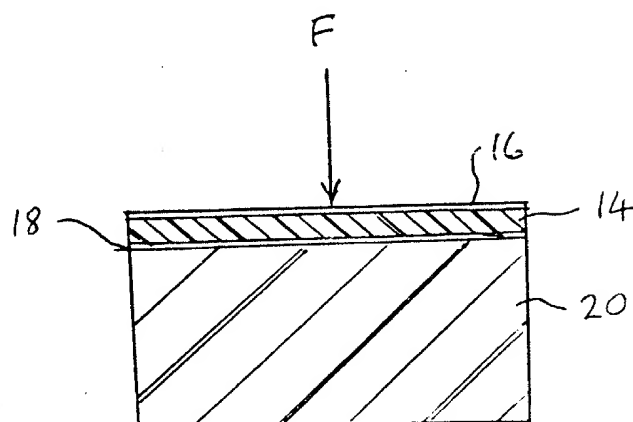


Fig.2

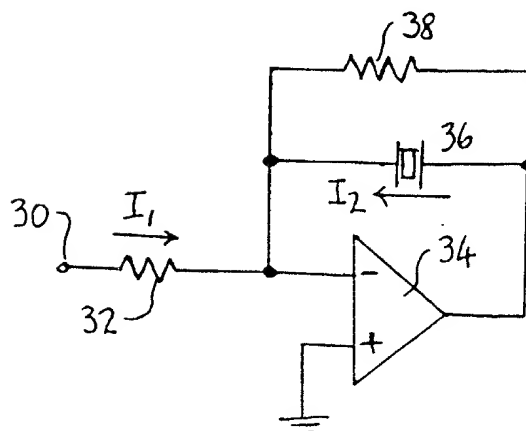


Fig.3

## SPECIFICATION

## Integrating amplifiers

- 5 This invention relates to integrating amplifiers comprising an operational amplifier with a capacitive feedback loop.

Such amplifiers are well known, using conventional capacitors as the feedback element.

- 10 The present invention is based upon the use as the capacitive feedback element of a device which acts also as an electromechanical transducer.

- There are a number of polymeric materials which exhibit a significant degree of piezoelectric activity, one such being polyvinylidene fluoride. It is known to use films of such materials having electrodes on their opposed surfaces as transducers, mechanical load being applied to the film either as compression or as stretching. However, voltage is produced across the electrodes as a function of the change in the applied load, not of the load itself, which has hitherto rendered such transducers unsuitable for use in d.c. or low frequency applications.

One object of the present invention, which is defined in the appended claims, is to overcome or mitigate this problem.

- 30 Embodiments of the invention will now be described, by way of example only, with reference to the drawings, in which:

*Figure 1* is a circuit diagram of a first embodiment forming a d.c. force transducer;

- 35 *Figure 2* is a schematic cross-section of a feedback element for use in the embodiment of Fig. 1;

- Figure 3* is a circuit diagram of a second embodiment suitable for transforming an electric signal into mechanical movement.

- Referring to Fig. 1, an operational amplifier 10 has one input grounded and its output connected by a feedback loop comprising capacitive element 12 to its other input. The circuit is thus similar to a conventional integrator. The capacitive element, however, as shown in Fig. 2 comprises a pvdf film 14 having on its opposed surfaces metallised electrodes 16 and 18, and mounted on a resilient support 20. The electrodes 16, 18 are connected in the circuit to act as capacitor plates, the film 14 forming the dielectric. If a force is applied as indicated at F, the film 14 is stretched and due to its piezo characteristic a voltage pulse is produced. This is integrated by the circuit arrangement, and the voltage output at 22 (Fig. 1) is effectively proportional to the applied force for as long as the force is maintained.

- 60 The embodiment of Fig. 3 is concerned with the inverse operation where an electrical signal is converted into mechanical force. Materials such as pvdf have a limitation in this application, in that their impedance drops as frequency rises. Thus if they are driven by a

- broadband amplifier high frequency inputs lead to amplifier runaway. In Fig. 3, an input signal at 30 is applied via resistor 32 to one input of operational amplifier 34, the other input of which is grounded. The output of amplifier 34 is connected by feedback path comprising pvdf capacitive element 36 to the first amplifier input. The amplifier acts as a virtual earth, and thus the current  $I_2$  through the capacitive element 36 is equal to the input current  $I_1$  through the resistor 32. Suitably, a second resistor 38 is connected in parallel with the capacitive element 36 to bypass d.c. and low frequency components. A mechanical force equivalent to  $I_1$  is produced in the pvdf element which may function, for example, as a headphone or loudspeaker.

## CLAIMS

- 85 1. An electric circuit comprising an operational amplifier having first and second inputs and an output, a feedback path connected between the output and the first input and comprising a capacitive element, the second input being grounded, characterised in that the capacitive element is a sheet of a polymeric piezoelectric material carrying opposed electrodes.

2. The circuit of claim 1, in which the capacitive element is adapted for the application thereto of mechanical force whereby the amplifier output is representative of d.c. forces.

3. The circuit of claim 2, in which said sheet is mounted on a resilient support such that said force causes stretching.

4. The circuit of claim 1, in which said first amplifier input is also connected to receive an input signal via a first resistor, whereby mechanical deformation of the capacitive element is produced representative of the input signal.

5. The circuit of claim 4, in which a second resistor is connected in parallel with the capacitive element.

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